Exploring the Connection between Color Hues and Perceived Eco-friendliness using Grocery Products

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ABSTRACT

This paper explores the impact of color hues on people's perception of the eco-friendliness of grocery products. Various products (frozen peas, milk, olive oil) images from Europe, Africa and Asia were selected and recolored in five different color hues. The participants were asked to rank each recolored product using a Likert Scale from 0 to 5 based on their personal eco-friendliness perception. The analysis revealed a statistical significance significance (p-value 0.0029<0.05) between the colors and their recorded eco-friendly scores. On average, a green hue received the highest score ($Med_{GRN} = 2.33$), following with blue and purple ($Med_{BLU} = 2.11$, $Med_{PRP} = 2.00$) whereas pink received a slightly lower score ($Med_{PNK} = 1.8889$). Orange had the same average score ($Med_{ORG} = 2.00$) as purple however had a slightly lower interquartile range. Further, given the RGB color model this research indicates an association with higher perceived eco-friendliness for colors with a high green and blue channel. Our findings imply that for practical application, color hue alone is not enough to establish an eco-friendly perception.

Author Keywords

low-saturation, color, warm, cold, sustainability, color hue, eco-friendliness, perception, grocery products

CCS Concepts

•**Human-centered computing** → *User studies;*

INTRODUCTION

In the highly competitive consumer landscape, the presentation of a product is a crucial factor in shaping the perception of its quality and value. A product's visual attributes, such as its color, can greatly influence the consumer's decision-making process and purchase behavior. In this context, color has been identified as a key element of marketing communication and is known to have a significant impact on consumer behavior [4].

While color has been extensively studied in the context of marketing, its influence on the consumers' perception of sustainability and eco-friendliness has received relatively little attention. Therefore, this paper seeks to investigate the perceived influence of color on the consumers' understanding of sustainability and eco-friendliness. Specifically, we aim to examine whether certain colors are associated with sustainability and eco-friendliness. This study has the potential to shed light on the role of color hues in shaping consumers' attitudes towards sustainability and eco-friendliness, and can provide useful insights for marketers and product designers seeking to communicate sustainability and eco-friendliness to their target audience.

BACKGROUND

Color has been identified as a primary cue for developing marketing strategies across various cultural backgrounds. In this regard, the study conducted by Madden [4] found that consistent interpretation of color and their combinations across different cultures can be applied for brand marketing strategies while developing logos. The study also revealed that colors have an array of meanings associated with them. Research conducted by Simona et al. [7] found that colors such as green are perceived as more eco-friendly in retailer logos, whereas red is not. The study also revealed that color perception varies between females and males, but the effect can be mediated due to processing fluency.

Another study conducted by Chu [1] found green and earthy colors are considered eco-friendly. They found green to be associated with foliage, grass, trees, etc. They also found the use of Green and Earthy colours to have increased from 2006 to 2010 however, the research is limited to fashion products and does not consider different hues and chroma of colors.

Pichierri et al. previously investigated the relationship between color saturation and consumer perception of product sustainability. In their paper, [6], five experimental studies were conducted to explore whether consumers associate low color saturation with a product's gentler impact on the environment. During these experimental studies, multiple products were color-coded with a high saturated color and a low saturated counterpart. The findings suggest that low saturated colors are perceived as more gentle and sustainable.

Another recent paper, investigated the impact of color on perception of healthiness, sustainability, and tastiness [3]. Multiple products were color coded either with a cool or a warmer color. It was found that cooler colors are perceived as healthier and more sustainable.

Considerations for studying color perception on digital screens

For our color selection process, especially given that electronic monitors primarily render colors in the RGB format, it was important to acknowledge the varying sensitivities of the human eye to different color hues. For instance, while traditional color spaces like RGB might suggest comparable brightness, human perception often results in blues appearing darker than for example yellows. To address this, the LAB color space (now superseded by OKLAB [5]) was introduced by the International Commission on Illumination (CIE) in 1976 [2], which takes into account the unintuitive behavior of human eye sensitivity. This enables the manipulation of color hue without influencing the perceived saturation (chroma) or brightness. Despite slight variations still being noticeable, when acknowledging the inherent variations in individual color perception, they were deemed acceptable for the purposes of this study, with any observed differences considered within reasonable limits. The OKLCH color space, a derivative of OKLAB, emerged as a suitable choice due to its ability to independently manipulate Lightness, Chroma, and Hue. In OKLCH, similar to the corresponding HSL model of the RGB color space, the hue value is defined within a range of 0 to 360, corresponding to degrees on a color circle.

METHOD

In this section, we will describe the methods used for the selection of colors that we've worked with, then go into details of survey, experimental design and execution. Finally, we finish this section with a description of the data analysis methods used.

Selection of Colors

In order to conduct a thorough investigation into the relationship between color hues and the perceived eco-friendliness of grocery products, a differentiated selection process was employed to ensure diversity in the chosen colors derived from the color circle. Considering the paper's sole focus on color hues, selection criteria focused exclusively on those, deliberately excluding considerations of variations

in lightness or saturation. For that reason, we determined it to be important, that the selected colors shared similarities in terms of the latter two attributes. As discussed in the background, it is important to acknowledge varying sensitivities of the human eye and as such we have chosen to use the OKLCH color space as a tool for our color selection.

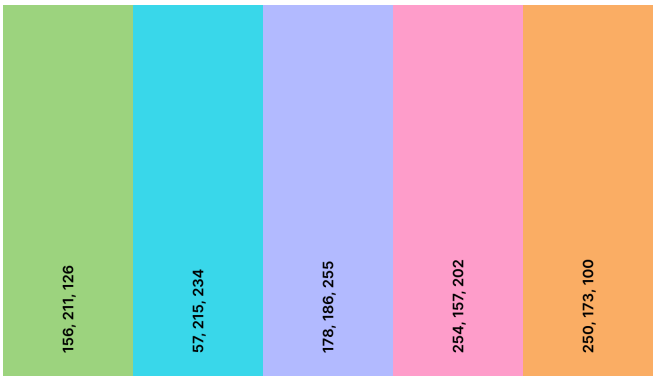

Figure 1. The OKLCH Colour palette with their respective RGB values. From left-to-right: Green (GRN), Blue (BLU), Purple (PRP), Pink (PNK), Orange (ORG) respectively

Five distinct colors were deliberately chosen, spaced evenly apart in hue within the OKLCH space. While the specific colors were selected arbitrarily, efforts were made to ensure that they were easily distinguishable by the authors, contributing to the diversity of the color palette. Considering the findings of a study by Pichierri et al. [6], which suggested that lower saturation contributed to perceptions of sustainability, deliberate decisions were made to maintain relatively low chroma and lightness. The chosen colors, as illustrated in Figure 1, were applied to the designs of product packaging. This application ensured the inclusion of at least one prominent area featuring a uniform color, with careful consideration given to the legibility of text and the preservation of the overall design integrity, focusing solely on the alteration of color hue.

To replicate the coloring process, the Adobe Photoshop "replace color" function was employed, complemented by handcrafted application masks for each product image. Stringent measures were taken to avoid any unintended modifications to logos,

Figure 2. Sample product color variation with products from Europe.

trademarks, or other insignia associated with the products. To mitigate potential familiarity bias linked to participants' knowledge of specific products, items were deliberately sourced from three distinct continents. This not only mitigates biases related to prior knowledge but also enhances the global applicability and generalizability of our research findings. With these measures, the geographic diversity of the selected products ensures that our study outcomes can be applied to a broad, international context. The products and there respective color variation for europe, asia and africa are shown in Figure 2, Figure 3 and Figure 4.

Participants

When choosing participants and in order to ensure the generalizability and relevance of our findings, we aimed to enhance the global context of the study by including participants from different continents, with a particular focus on Europe, Africa, and Asia. The process of participant recruitment involved the distribution of a survey across various social media platforms (WhatsApp, Discord, Instagram, etc.) with the goal to maximize the number of participants

Figure 3. Sample product color variation with products from Asia.

Figure 4. Sample product color variation with products from Africa.

and increase the likelihood of obtaining a diverse sample.

The study includes data from a total of 44 responses from survey participants. Gender distribution was fairly uniform, with a slightly higher representation of females (N=25), males (N=19), "Trans-gender", "Non-binary", "Prefer not to say" and "other" (N=0). Ensuring that gender bias can be safely ruled out. In terms of age, participants spanned a range from 17 to 59 years, with a notable concentration in the 20 to 29 age group, with half of all participants (N=22) lying within that age range. Nonetheless, this represents a notably diverse set of participants. Geographically speaking, half of the participants were from Germany, demonstrating a considerable representation from a single country. Additionally, approximately two-thirds of total participants originated from Europe, representing a clear bias that we considered in our data analysis. Considering that 14% of participants were from Asia and 12% from Africa, we certainly achieved our goal of a global target group. The remaining participants hailed from North and South America, adding to the diversity of the overall sample.

Survey

During our survey, we had specific requirements, such as the need for timed questions, a customized structure for readability, and responsiveness across mobile devices. After evaluating different survey tools, we chose "LimeSurvey" because it met our demands better than the other tools we considered, such as Google Forms, Microsoft Forms, Survey Monkey, and Typeform. This was especially important during our pilot phase when we needed to test the participants' responses by timing each question to 10 seconds. "LimeSurvey" offered us high customizability, allowing us to personalize the questions using user-defined HTML, CSS, and custom scripts. Additionally, the questions' layout was responsive on all devices and screens, which was essential as most of our survey participants used their phones or tablets.

A preliminary investigation was undertaken through a pilot study comprising 5 randomly selected participants. The study aimed to assess the viability of the experimental design and identify potential issues before the full-scale implementation. The pilot survey setup involved the distribution of 60 grocery product

questions. These 60 questions were the outcome of four distinct essential grocery products from three continents that are recolored in 5 different colors, each subjected to a 10-second time constraint. To account for randomization in the survey, a Within-Subject design was employed to enhance the generalizability of the findings and mitigate potential biases. This was mainly done as separability between treatment conditions for a Between-Subject design was unknown. During this first phase of the study, core questions' clarity and appropriateness we evaluated. This step was essential to identify any potential issues with the questions and make necessary changes to improve the questions' quality, thus increasing the chances of obtaining accurate and meaningful results in the subsequent stage of the study.

The participants in our pilot study shared their feedback on various aspects of the study. Many of them found the timer popup to be confusing and reported feeling stressed out by the timer in general. Additionally, there was initial uncertainty about the survey's focus (packaging vs. color), and mixed opinions on survey length, with some finding it too long and tedious to answer. Based on this feedback, we decided to remove the timer feature and one of the grocery products, canned tomatoes, which resulted in the elimination of 15 product questions. As a result of these changes, the total number of grocery product questions went down from 60 to 45.

Our final survey consisted of a total of 52 questions, which included 45 randomized questions about different grocery products, followed by three profiling questions, and lastly, four demographic questions. To avoid priming the users, we gave minimal guidance about what to expect before starting the survey besides an initial welcome landing page. After a short introduction paragraph, the survey began by asking 45 questions about different grocery products; the question text was the same, but the grocery products were randomized; we asked users to rate each product's eco-friendliness using a 5-point Likert scale. The scale ranged from 0, which meant "not eco-friendly at all", to 5, which meant "extremely eco-friendly".

> *How Eco-friendly do you perceive this product to be? (0-5)*

Users were then asked three profiling questions as follows:

> *[1] Please rank these colors based on your preferences. Top = most favorite color. (Reorder-Box)*
>
> *[2] In regards to "Your Environmental Proactivity." Which best describes you? (Select one: Completely Inactive - Mostly Inactive - Somewhat Proactive -Extremely Proactive)*
>
> *[3] Why do you perceive certain colors as eco-friendly, and Which are they? (Text-Box)*

Lastly, we finished our survey with 4 demographic questions as follows:

> *[1] Where are you from? (Text-Box)*
>
> *[2] How old are you? (Numbers-Box)*
>
> *[3] What's your Professional Status? (Select One: Student - Employed with salary - Self-employed - Military - Retired - Out of work / Not Working - Other)*
>
> *[4] What gender do you identify as? (Select One: Male - Female - Trans-gender - Non-binary - Prefer not to answer - Other)*

Data Analysis

After the experiment, both quantitative and qualitative data analysis was performed. Data points which contained only the same option throughout without sufficient qualitative description were considered as outliers and removed. About $n_T = 81$ data points were collected through the survey, of which 37 data points that were partially filled were discarded to account for statistical testing. The survey had an 54% completion rate with 44 data points remaining for final analysis. In a meta-analysis of online-surveys conducted by [8] found the average response rate was found to be 44% for educational surveys. Thus, our response rate should yield accurate results. As

stated aiming for an even higher response rate by sending it to a larger population without a target-group will effect data quality of responses leading to non-response Bias. In our survey, the non-responses might be influenced to a certain degree by inclination away from Sustainability related topics or disinterest in providing feedback altogether. The quantitative data was analyzed for statistical significance on the comparison data. Data was grouped and averaged based on unique region and product, as well as for each product. Since the data is not normally distributed, we cannot use a parametric test such as *ANOVA*. The scores (outcome variable) are considered as Ordinal and color features are considered as categorical, hence a non-parametric test such as *Kruskal-Wallis H Test* is employed to test whether a significant difference in perception exists. The tests were performed on the median value of the sustainability perception scores to different colors.

The data acquired from the free text box question was used to interpret and associate with the results from Quantitative analysis. Since the answers were seldom longer than a sentence, they provided an explanation to participants ratings of different scenarios. We resorted to visualizing the Qualitative data using Word Clouds instead of using a theoretical framework such as Thematic Analysis or Clustering, as we wanted to prevent bias towards certain categories given the sparseness of data.

RESULTS

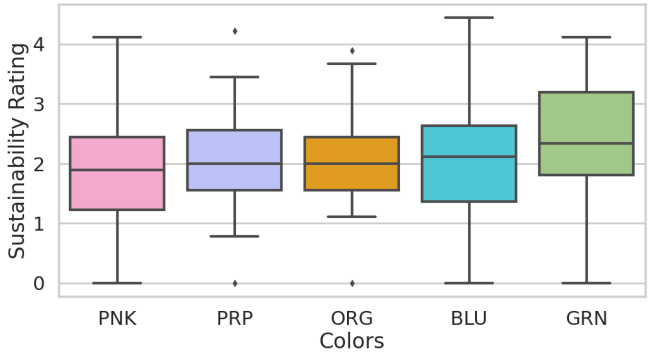

Figure 5. Global Sustainability Ratings for different colors averaged across unique Product-Continent combination.

Figure 5 illustrates the global perceived eco-friendliness across continents and products. The average was taken based on the continents and products respectively. As seen in the plot, green is perceived as the most eco-friendly across continents as products, resulting in a median of $Med_{GRN} = 2.33$, followed by blue with a median score of $Med_{BLU} = 2.11$, orange as $Med_{ORG} = 2.00$, purple $Med_{PRP} = 2.00$ and lastly pink with a median of $Med_{PNK} = 1.8889$. Our hypothesis test using Kruskal's method showed a p-value of 0.0029<0.05, proving there is a significant difference in sustainability perception of each color as observed in Figure 5.

The Interquartile range(IQR) of the colors has a lot of divergence as well. For instance purple and orange have only a small divergence ranging from $Q1_{ORG} = 1.55$ to $Q3_{ORG} = 2.44$ for orange and purple from $Q1_{PRP} = 1.55$ to $Q3_{PRP} = 2.56$. On the other-hand, there is a lot of variation in the other colors. Especially blue which while the median lies at 2.11 which sits fairly close to green there the Interquartile range sits at $Q1_{BLU} = 1.36$ to $Q3_{BLU} = 2.63$. Green and blue which have the highest medians are the colors which are mostly associated with eco-friendliness and therefore sustainability. Moreover, we notice purple and orange have almost no significant difference given their p-value of 0.79>0.05 despite the qualitative data showcasing otherwise.

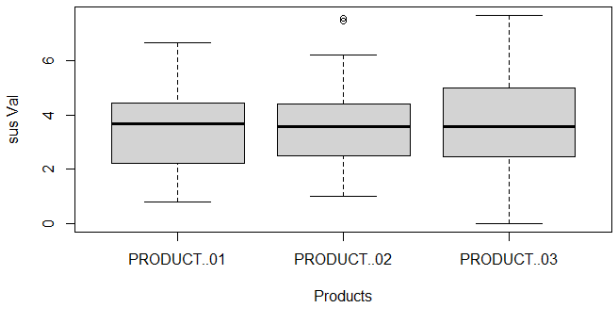

Figure 6. Global Sustainability Ratings for different Products

Figure 6 illustrates that overall, there is no data which indicates that a certain product type influ-

ences the perceived eco-friendliness of the participants. Therefore, further analysis was not required.

Figure 7. Variation in Sustainability Perception Scores visualized across Products,Continents and Colours.

Figure 7 shows the average score of the colors in relation to the products and their respective continent, indicating a noticeable difference in perceptions across continents. On average, people from Europe perceived all tested colors as more sustainable in comparison to Asia and Africa. Further, Europe favored the first product category in terms of eco-friendliness, while this product performed worse in Asia. In Europe, green-colored products consistently score high in eco-friendliness, while in Asia, there's a more varied response across different colors and products. Further, an investigation was made whether there is a significant divergence between genders. Resulting in a median of $Med_{Female} = 2.08$, $Med_{Male} = 2.26$. However, given a p-value of 0.290 no significant data was found.

A word cloud was created representing the global qualitative data from the participants (Figure 8).

Synthesis of Results

To review whether there is a correlation between certain color channels and the sustainability score, the colors and their distinct color channels were normalised and compared (Figure 9). It's particularly interesting how the R, G, B color channels interplay with each other as shown in Figure 9. A high red channel is more associated with a low sustainability score, while a high blue or green channel might be

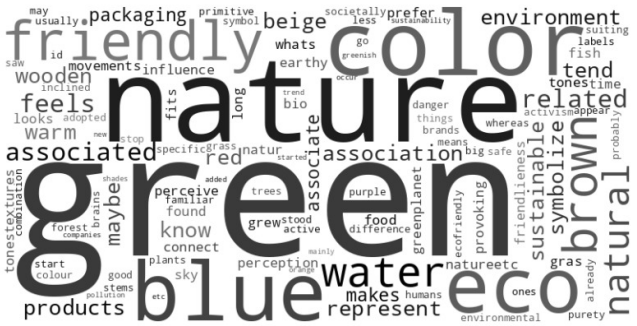

Figure 8. Word Cloud of Qualitative Responses

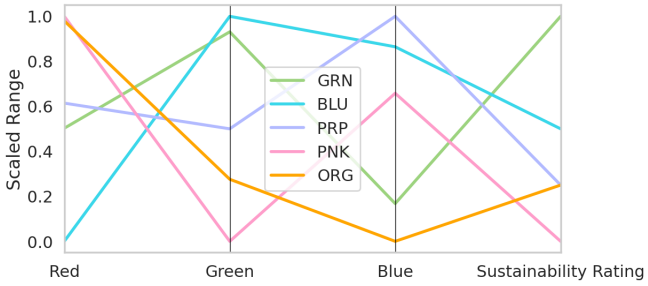

Figure 9. Interaction between RGB values and final eco-friendliness scores

associated more with a high sustainability perception.

DISCUSSION

Understanding when, and how colors are perceived by people is an interesting problem in HCI with many implications to the real world. Since this was a study conducted with people across the globe, interesting insights emerge between the product groups, their colors and their respective continent.

For instance, Appendix Figure 7 illustrates noticeable differences in the perceived sustainability of products across the continents, suggesting cultural or regional differences in how eco-friendliness is perceived. The three different products received varying eco-friendliness scores. This could be influenced by the specific design, use or marketing of each product, indicating that eco-friendliness perception is not solely based on color. Some combinations, such as the green-colored product 01 in Europe, show a high level of agreement among respondents, as indicated by the high average score. This could mean that certain product-color combinations are universally perceived as more eco-friendly.

This also suggests varying inclinations of people across different cultures on sustainability and environmental movements:

Based on our qualitative analysis, there were individual inclination to sustainability. Some participants mentioned that colors do not influence their perception of eco-friendliness. Others mentioned that they are more inclined to look at labels and their specific packaging. Further participants mentioned that the color green has been already associated with the pro-environmental movement indicating a association with color eco-friendliness and political views.

Individual Inclination to Sustainability

> *Color does not influence my perception of eco friendlieness*
>
> *As I am more active with environmental activism I am more inclined to look at specific labels on the packaging.*
>
> *No.*

Color Association with exposure to Eco-Friendly Marketing:

> *eco friendly products have been associated with the colour green for a long time to represent 'green' movements and the environment*
>
> *... sustainable brands tend to have already adopted green as a symbol colour so maybe our brains just start to expect that association.*
>
> *Since sustainability started to be a new trend in companies, they have added green and blue colors to associate them with nature and water*

Given the small sample size we notice a small group of participants accounting to 8.5% of responses as having personal biases in their choices. This is interesting as the following effect might scale based on locations, cultures and larger sample sizes.

Color Association with Nature: Other participants mentioned that there might even be an acceptance from people and companies towards green and blue as a symbol for sustainability associating it with nature. Green-colored products generally received higher sustainability scores across most continents and products. This could indicate a psychological association of the colors with natural elements and thus with eco-friendliness or sustainability, as is evident from our qualitative responses Figure 8. Based on the qualitative data, some participants even mentioned perceiving blue as more sustainable than green. Due to the abundance of less saturated colors in nature, the perceived environmental friendliness could be increased with the selected color palette.

> *blue and green represent sky and water, so this is the reason I prefer blue and green the most sustainable one*
>
> *I perceive colors that I connect with nature as eco friendly such as green, beige or earthy tones or wooden tones/textures*
>
> *Green, natural wooden colors because that's what's found in the nature I grew up with.*

More than 50% of the survey respondents mentioned Green and around 22.8% mentioned Blue, 20% mentioned Brown/Beige/Wooden textures out of all responses. We notice approximately 31.4% explicitly associated these colors with natural elements. The implicit association is apparent despite the elimination of certain word usage to associate to nature.

Color Combinations and Symbolism While Green is generally perceived as the most eco-friendly color, other colors such as blue, purple and to an extent orange also receive high scores in certain combinations. Purple, although less represented in the top scores, still has a moderate perception of sustainability in some cases. This is due to how primary and secondary colors of packaging influence perception:

Based on the results of Figure 9, there might be an correlation with the perceived emotional state of the participant. Similar to how green is perceived as natural, red is associated with danger. This is aligned with our qualitative findings and explains

why purple has a moderate perception despite similar median scores. However, there is not enough data for a regression analysis to make any strong claims through quantitative data.

> *....Green also societally means "Go" or "Good" (whereas red may tend to symbolize "Stop" or "Danger)...I think this stems back from when humans were primitive and most of the things we saw in the forest was green so it was a safe colour but red was a less familiar colour.*

> *I feel it's more which colours appear more friendly while suiting the packaging as well makes a big difference. The combination makes it seem eco friendly. I'd say green and purple probably were the ones that most stood out to me.*

The following insights about color combinations and different colours having a symbolic meaning attached to them allows for design use in multiple settings. These include marketing campaigns, game or media production where different color combinations can be used to convey messages of sustainability. **Warm Colors:** In general warmer tones were associated with sustainability as indicated by a qualitative response from a survey part:

> *Warm colors, don't know why*

> *All colours that are warm and natural like brown and greenish colours seem to be eco friendly.*

> *.. Pollution - brown, orange*

This is in contrast with our background research, our results indicate that there may be an influence of perceived sustainability when using low-saturated colors in combination with warmer colors. While cooler colors are generally perceived as more sustainable, there could be a correlation in choosing low-saturated colors in combination with warmer colors.

Further, Simona et al. mentioned a significant variance in color perception between male and female [7]. Given our conducted study and the processed results, we could not acknowledge the same behavior. However, taking into consideration that this variance is based on achieving processing fluency by the participant, it could be that our participants were somewhat confused by the question design or distracted by the packaging design, suggesting that the conducted study in this paper likely didn't achieve processing fluency.

Application

Our findings can have practical implications for companies and designers in the domain of grocery products. Companies can leverage our insights by incorporating sustainable colors in their packaging design, where green hues, in particular, tend to enhance the perceived eco-friendliness across continents. This is applicable not only to physical packaging but also extends to online shops where color palettes play a crucial role in the overall design aesthetic. While we found a slight inclination towards green, our results suggest that the overall package design might be equally, if not more, important than the specific color hue. Designers should focus on the holistic presentation, considering factors beyond color hue, such as materials and visual elements.

It is moreover important to stress the difference between colors and color hues, with the color hue only being a part of the resulting color. It has already been shown, that the combination of low-saturation with cooler colors influences sustainability perception positively [6]. Brands with established color identities need not overhaul their hues entirely. Our findings imply that maintaining the hue while possibly adjusting saturation and lightness can preserve brand identity without significantly compromising the perceived sustainability.

At this point we feel it is necessary to mention, that companies should be cautious not to misuse these findings for greenwashing, presenting products as more sustainable than they truly are. Authenticity in sustainable practices is crucial to maintaining consumer trust. Overall design strategies for grocery

products require a holistic consideration of various design elements, not just color hue.

Future Research

An interesting direction for future research would be to explore how different packaging materials influence eco-friendly perception. Moreover, a more extensive study can ascertain whether our findings generalize to more products, or only groceries and impact across more continents. Another important area to research on is whether certain R, G, B combinations influence sustainability perception, given the odd nature of scores of both Orange and Purple. This could lead to formation of newer color palettes for enhancing Sustainable design.

Moreover, future research could take a look at how the other two aspects of the OKLCH color space affect the perception of eco-friendliness. While research already exists on the effect of saturation/chroma on the perception of sustainability, studying the importance of lightness might yet unveil interesting insights.

Additionally, the generalizability of the study results to other products than grocery packaging may be examined. We would like to note however that we already expect our findings to hold for most other consumer focused product packages.

Overall, these insights could be crucial for marketing strategies. For example, if a company is launching an eco-friendly product in Europe, using green might enhance the product's perceived eco-friendliness. However, the same strategy might need adjustment in Asia, where perceptions vary more broadly. The variation across continents highlights the importance of cultural and regional sensitivity in product design and marketing. What works in one region may not be as effective in another.

Strengths & Weaknesses

In the following section we discuss the strengths and the weaknesses of our research. The strentgths of this work include the noticeable evidence garnered for future research to develop better clour palettes for Sustainable design work. Moreover, given our low-saturations setting and finding of warm colours showing high perception shows that not just the color, but its constituent characteristics such as the chosen Color Space, Saturation,etc can also greatly contribute to Sustainability perception. One of the main issues with our work is the noticeable lack of data to make a strong hypothesis for different colour channel interactions and its effect on Sustainability perception. Also packaging design itself can effect to a certain extent the sustainability perception despite our findings. Due to the limited time constraint we could not evaluate all the demographic data.

CONCLUSION

In conclusion, this study aims to investigate the perception of eco-friendliness in relation to color hues, while taking into account regional and cultural differences. A survey was carefully designed to evaluate this influence of color hues for five types of grocery products (frozen peas, milk, olive oil) using two evaluation questions. The main results highlighted significant variations in the perceived sustainability of colors across continents, with green consistently rated as the most eco-friendly. This holds especially true for our European survey participants, while the results for other continents were more mixed. This suggests that the perception of a color's eco-friendliness factor is influenced by both cultural and regional factors.

Insights from the study can be practically applied in the design and marketing of grocery products, where incorporating sustainable colors, especially green hues, may enhance perceived eco-friendliness. Further research might investigate the role that not just color hues, but also a color's lightness plays in eco-friendliness perception. Additionally, an in depth analysis of holistic color values could provide valuable insights into this realm.

However, it is crucial for companies to avoid green-washing and prioritize development of products which are materially sustainable than relying on green marketing or green-washing as it is unethical practise to the consumer.

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